Algae Tech Conference

19-20 Sept-2018, Munich

LARGE RACEWAY DESIGN FOR WASTE WATER TREATMENT BY ALGAE CULTIVATION H2020 INCOVER PROJECT

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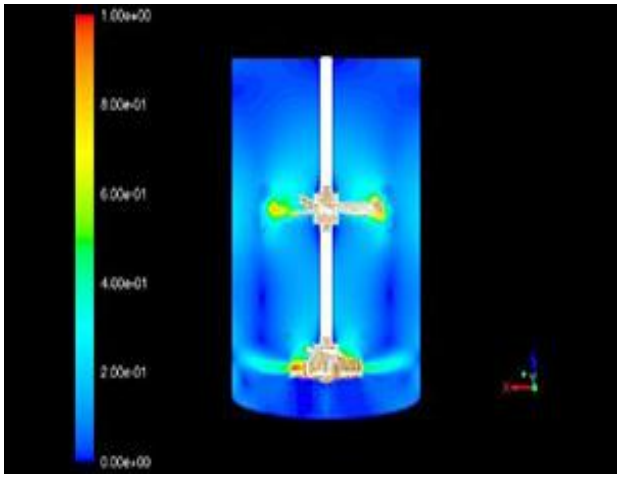
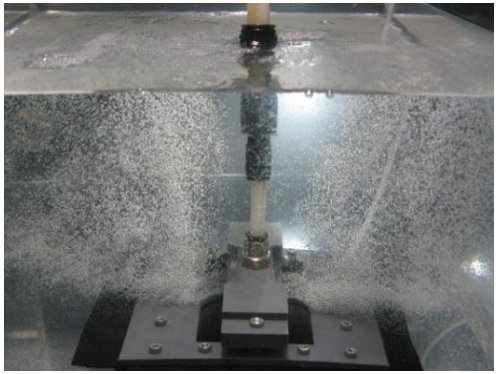
GAS-LIQUID MIXING AND BUBBLE GENERATION

- Spin-off, University of Seville
- Multi-Phase Flows
- Turbulence Models
- Particle Dynamics
- CFD Simulations
- Industrial equipment design



- **MIXERS**
- **REACTORS**
- **PILOT TESTS**



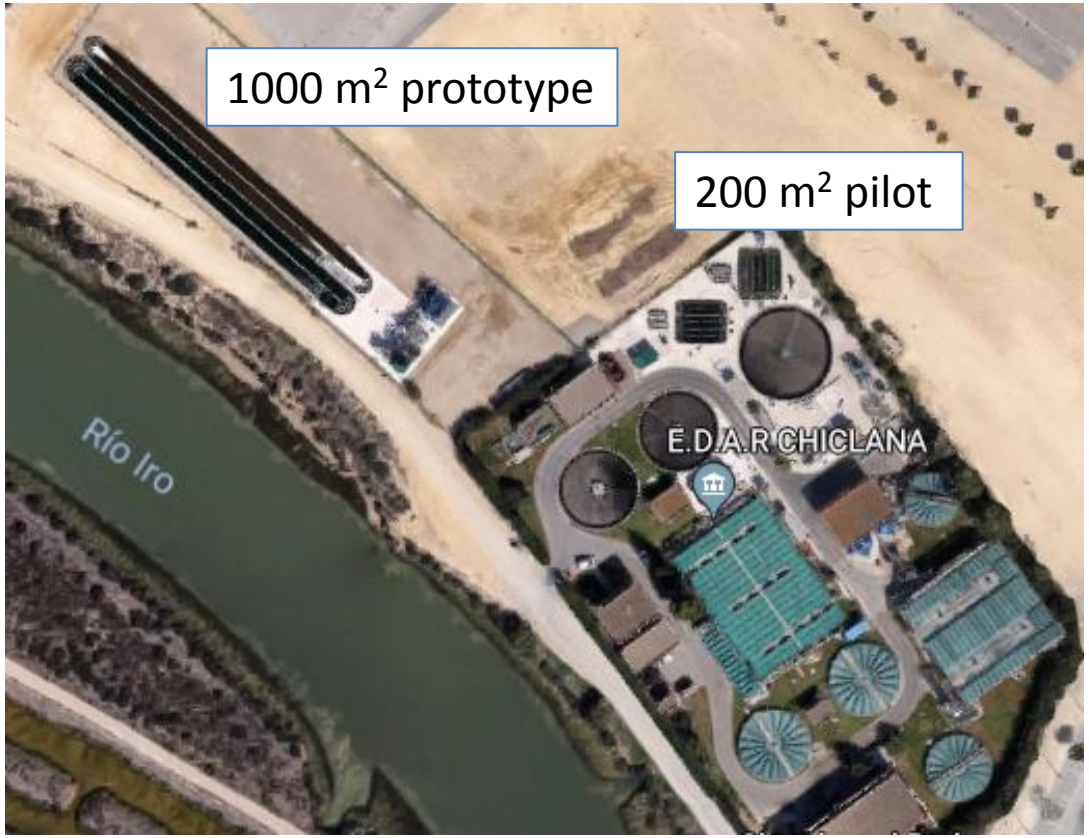
- **CFD** (*Computational Fluid Dynamics*)
- **MICROBUBBLE DIFUSERS**

WWT EUROPEAN PROJECTS

All-gas + Incover

www.all-gas.es

incover-project.eu



WWTP at Chiclana de la Frontera (Andalusia, Spain)

WWT EUROPEAN PROJECTS

2 Ha demo plant at Chiclana

4 raceways x 5200 m^2

INCOVER objective: **100.000 population equiv.**

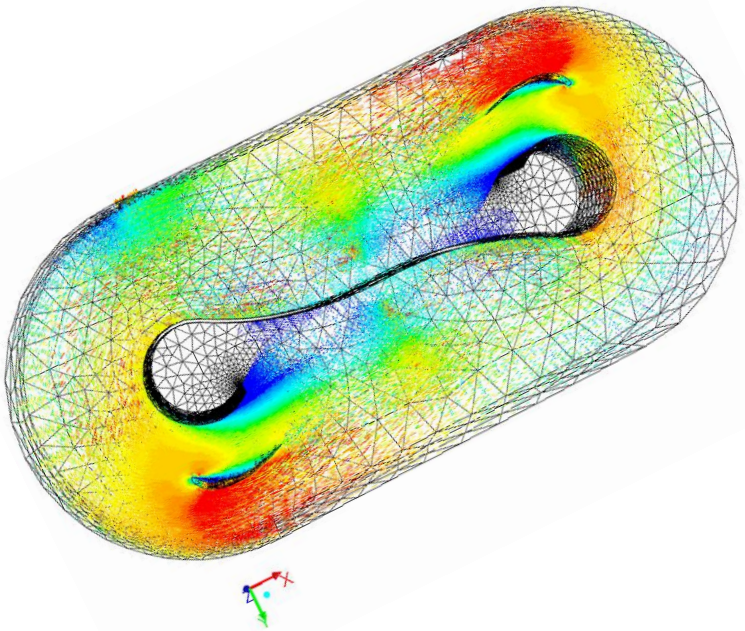
LARGE INDUSTRIAL RW DESIGN

- New HRAP driving system (LEAR)
- Geometry optimization of suction and returning curves

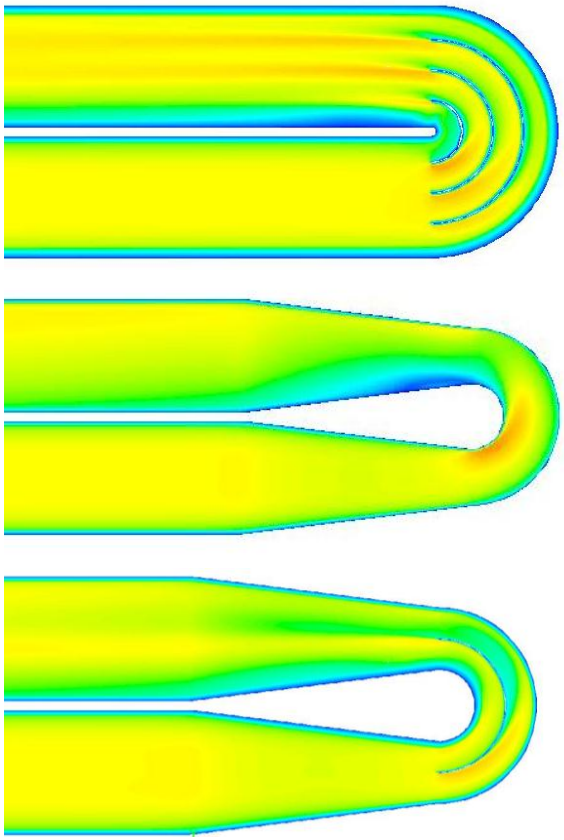
Power reduction

- Experimental validation
- Paddle-wheel characterization
- Stirring by vortex generation

Mixing



GEOMETRY OPTIMIZATION



ΔP = 32 Pa

ΔP = 25,1 Pa

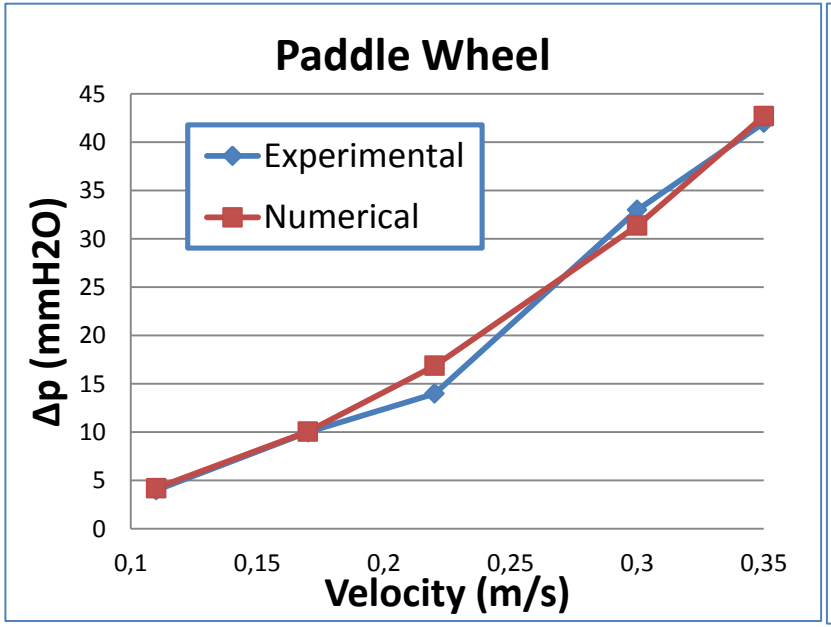
ΔP = 18,3 Pa

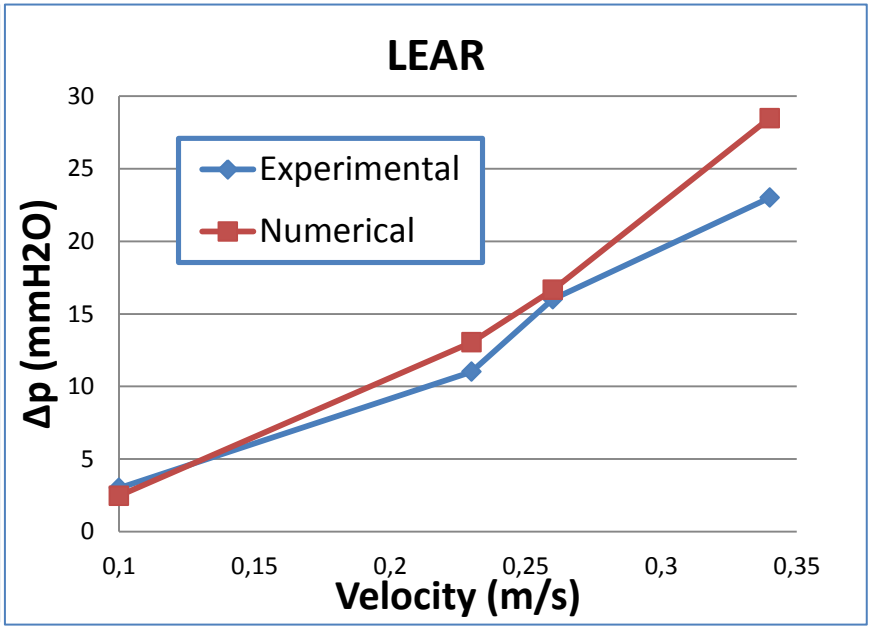
500 m^2 raceways
Hydraulic energy loss

$\Delta P_{friction}$ ~ 200 Pa

EXPERIMENTAL VALIDATION

Hydraulic pressure drop





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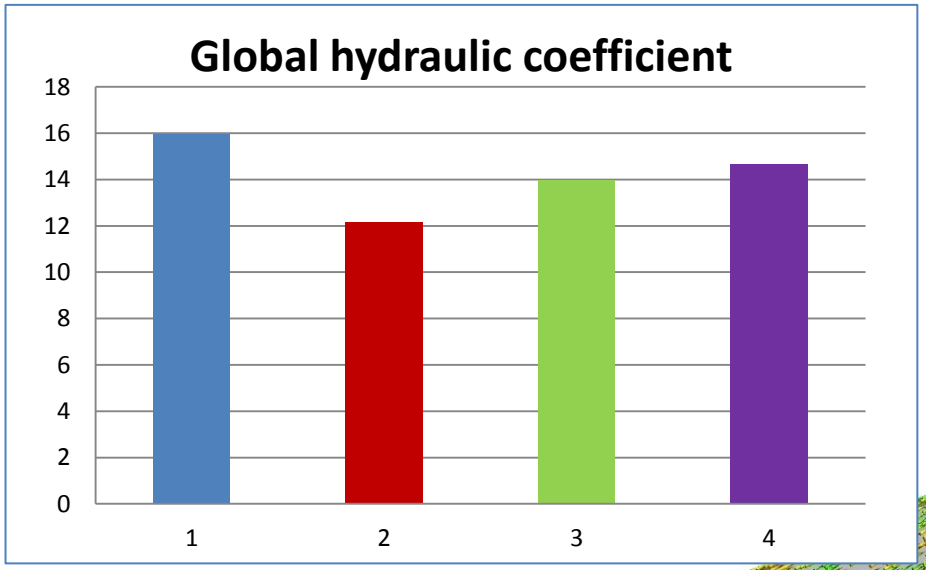
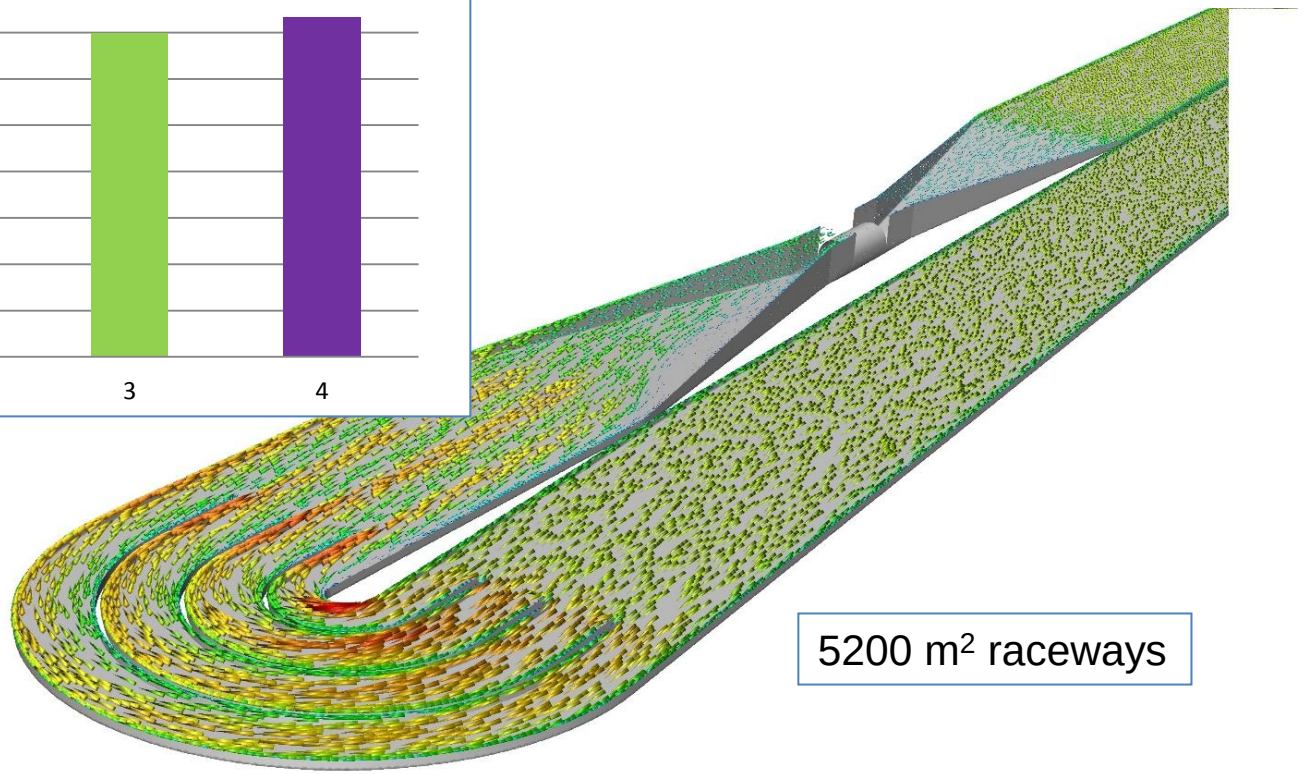
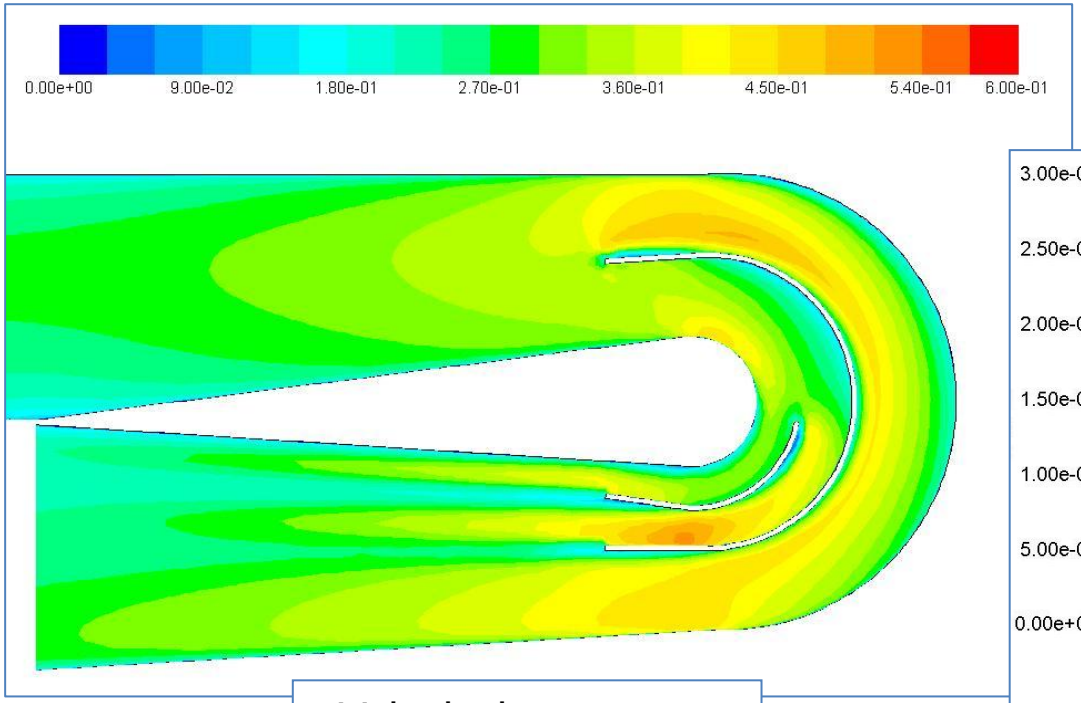




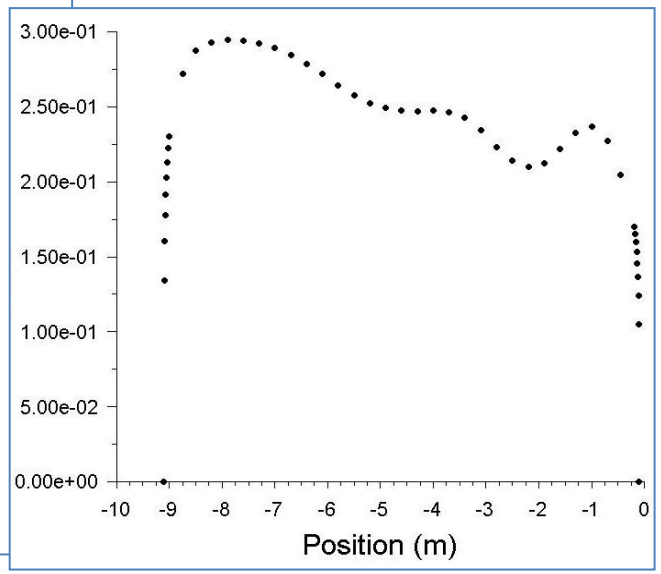
5200 m² raceways

GEOMETRY OPTIMIZATION

Flow uniformity



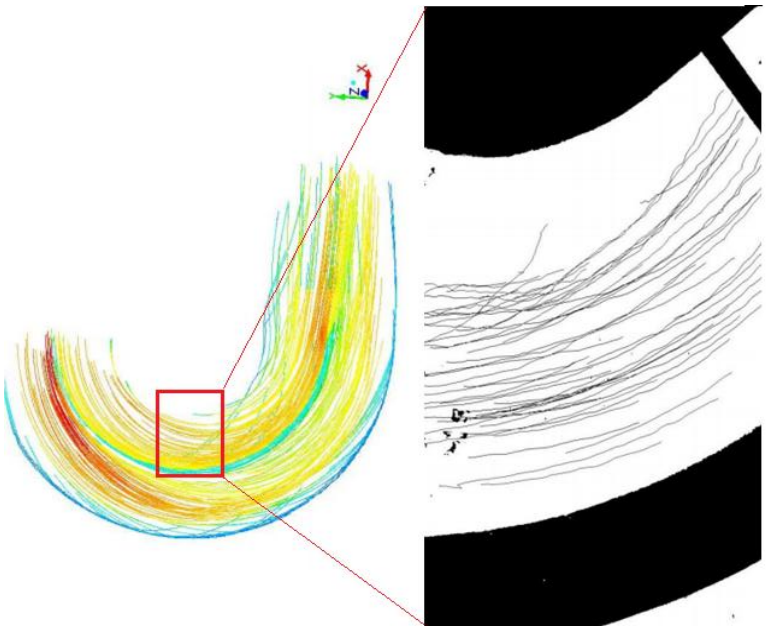
Velocity isocontours

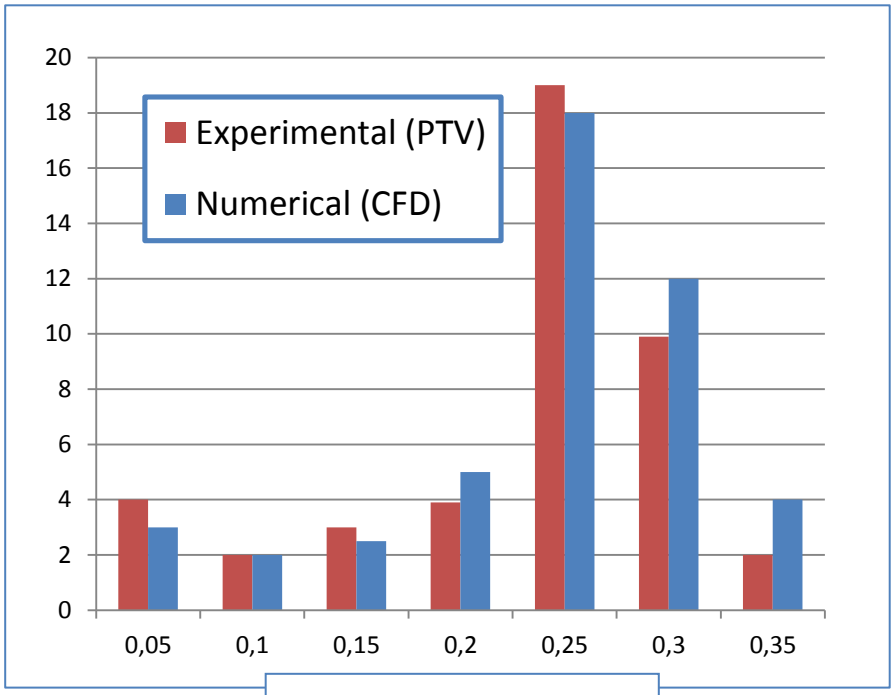


Velocity profile at curve exit

EXPERIMENTAL VALIDATION

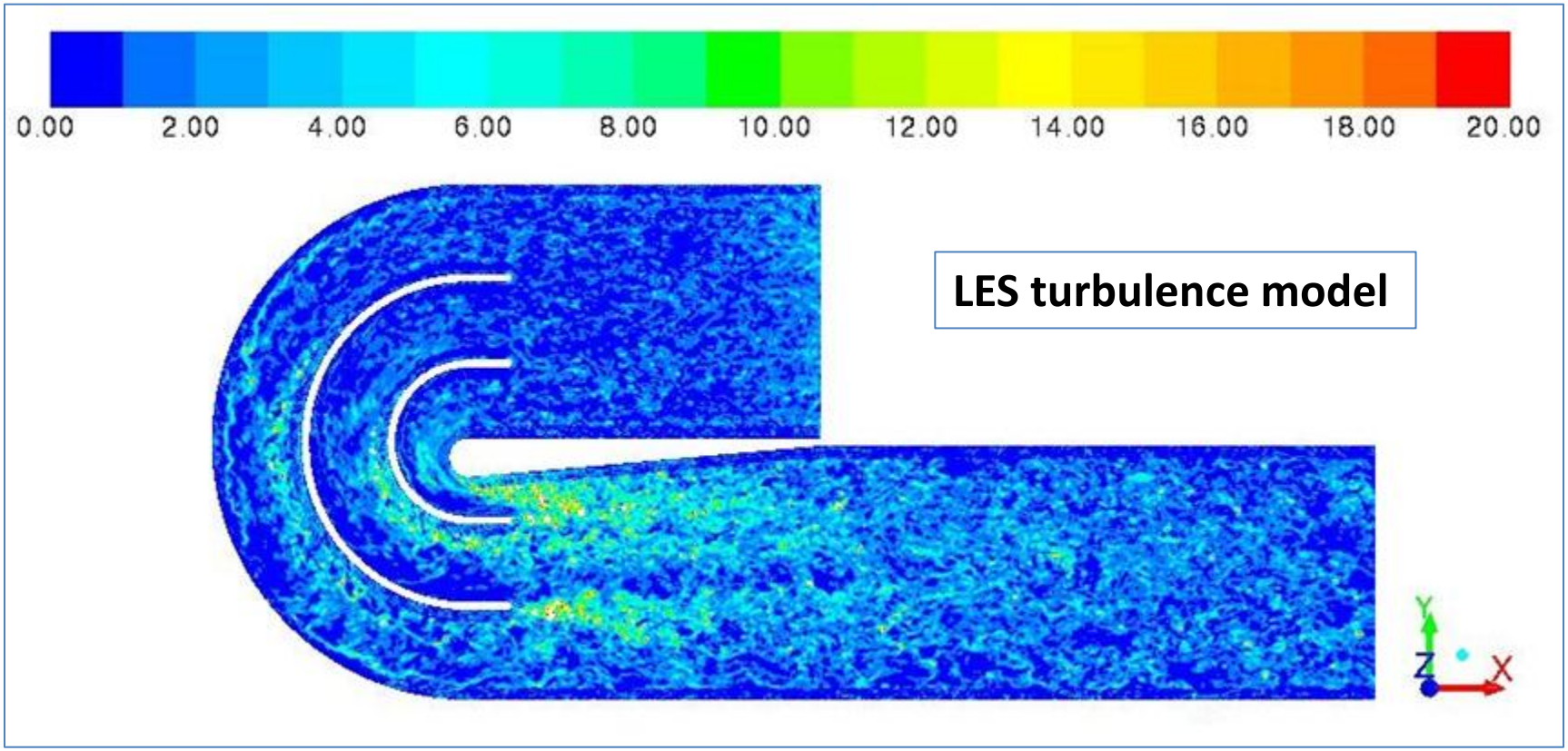
Particle trajectories





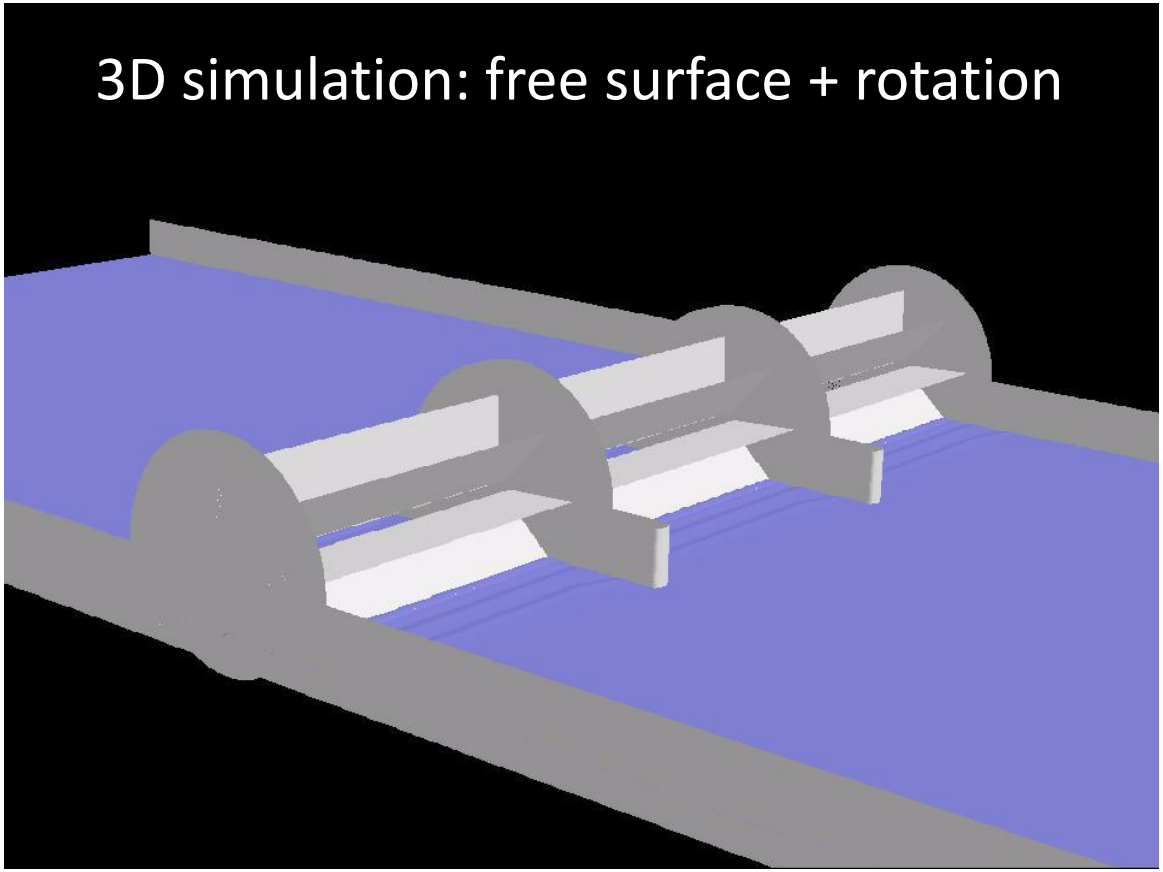
Velocity histogram

GEOMETRY OPTIMIZATION



Isocontours of **turbulent viscosity**

PADDLE-WHEEL CHARACTERIZATION



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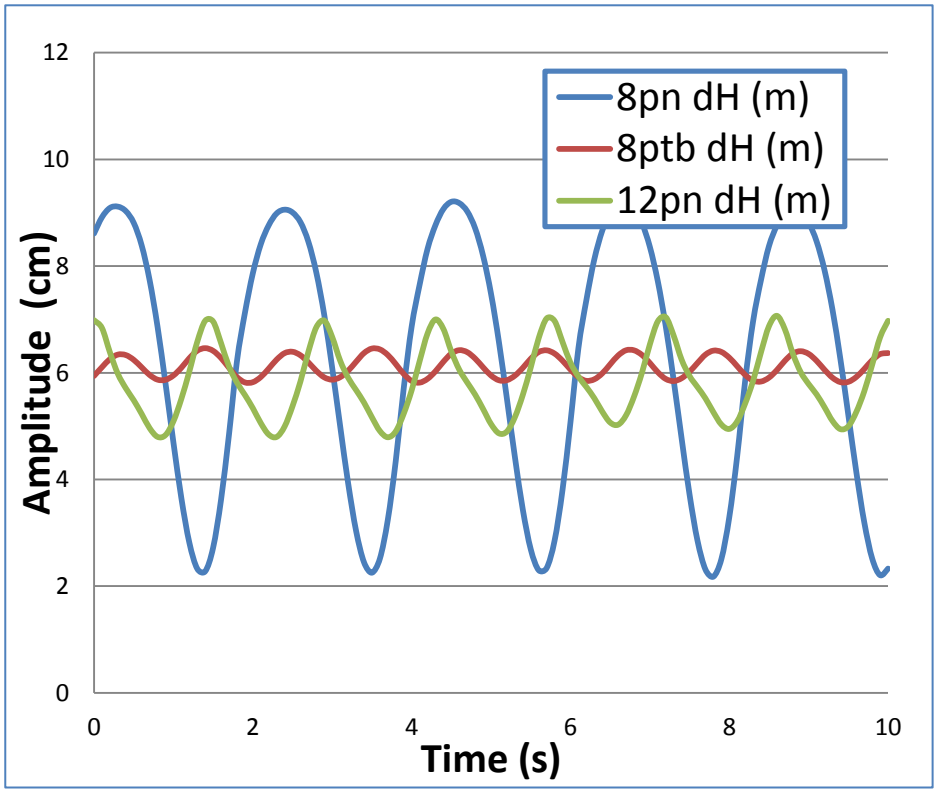
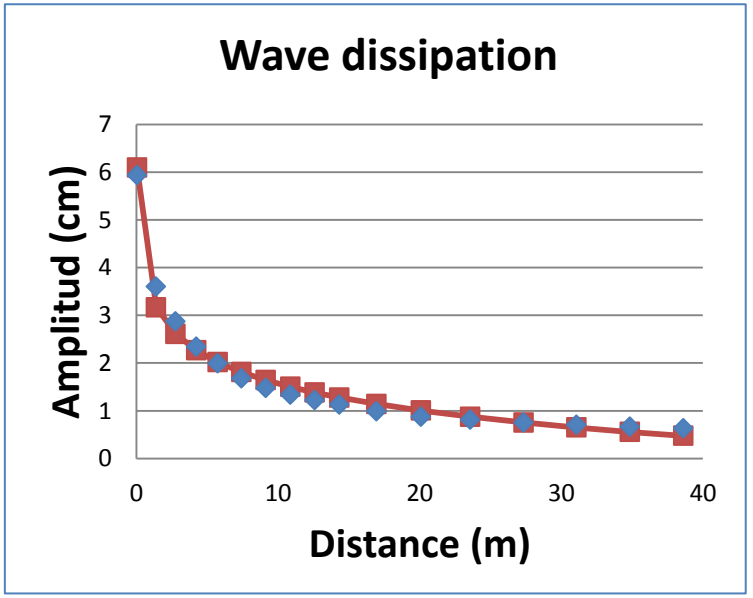
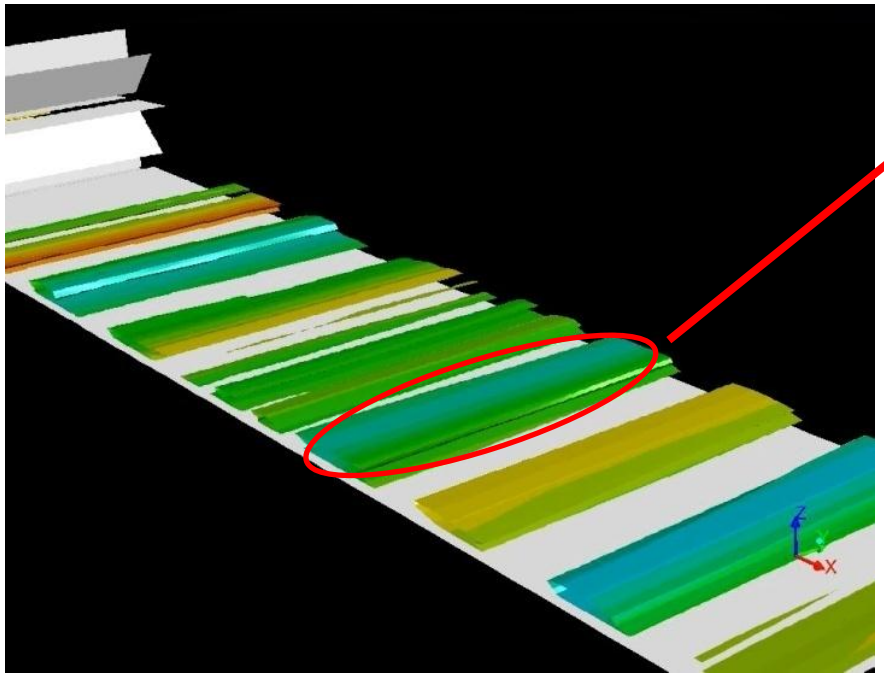




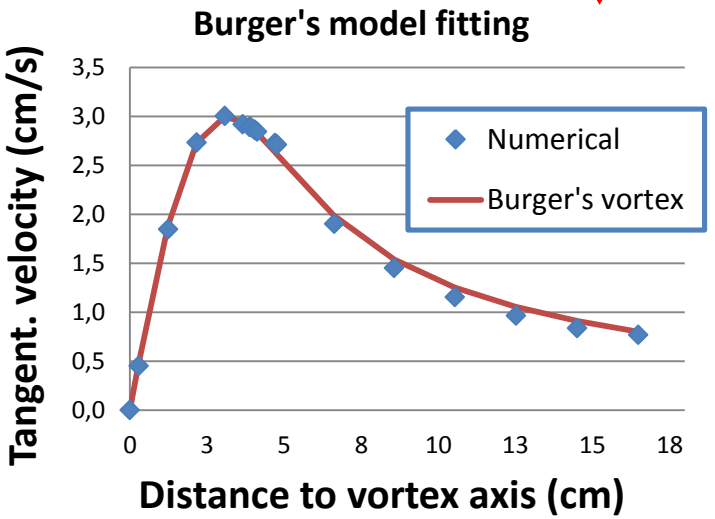
Amplitude of the waves generated by different paddle-wheels

PADDLE-WHEEL CHARACTERIZATION



Vorticity isocontours

Vortex tubes associated with paddle-wheel waves



VORTEX GENERATION

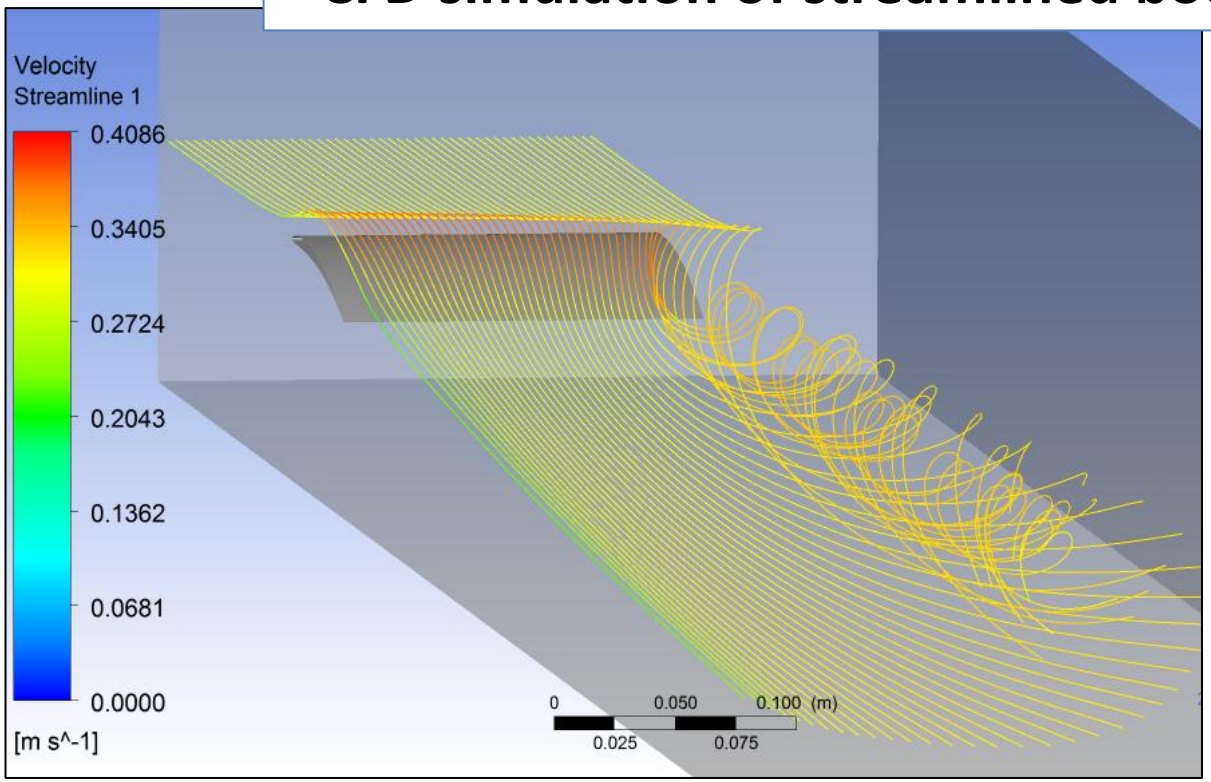
AERODYNAMICS ⟺ **Efficient generation of high and low pressure regions**

Drag and Lift forces ⟺ **Intense and long vortex tubes**

VORTEX GENERATION

Patent of the University of Seville

CFD simulation of streamlined bodies



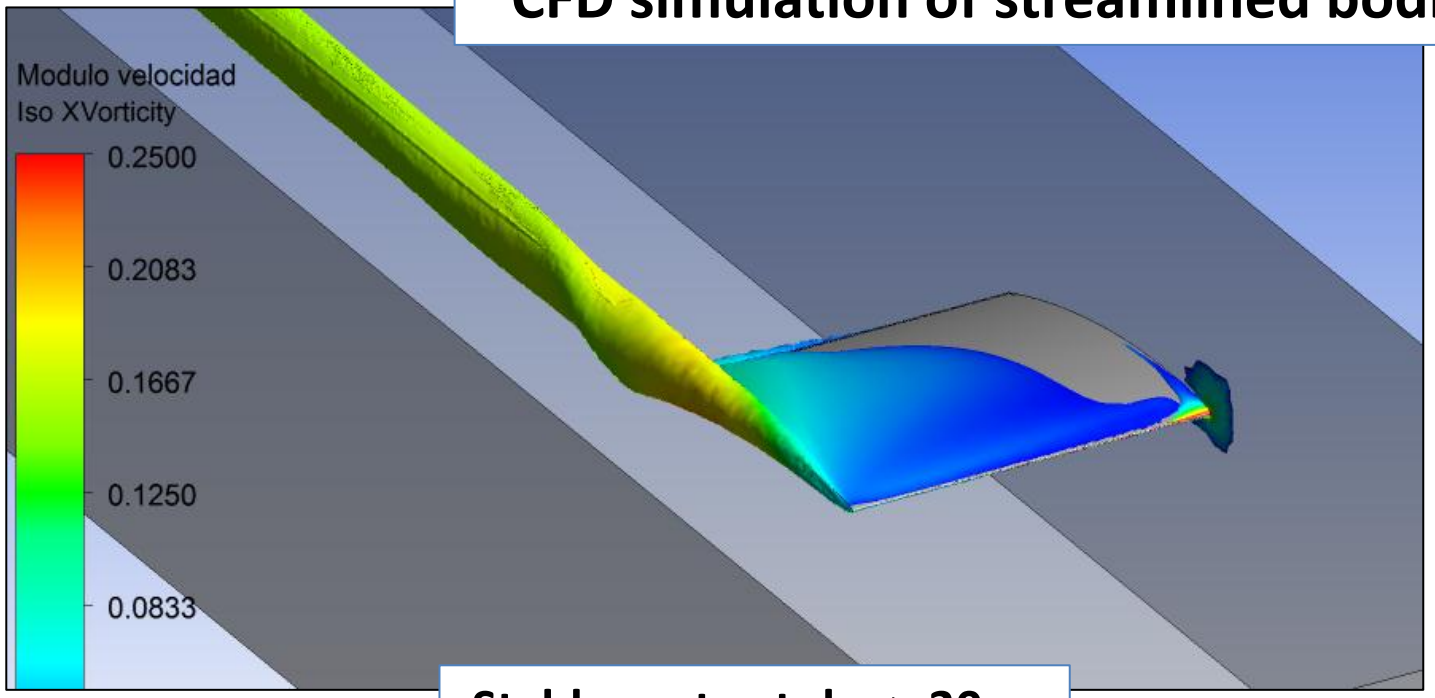
vortex intensity and aerodynamic drag

ΔP = 0,3 mmH_2O

VORTEX GENERATION

Patent of the University of Seville

CFD simulation of streamlined bodies



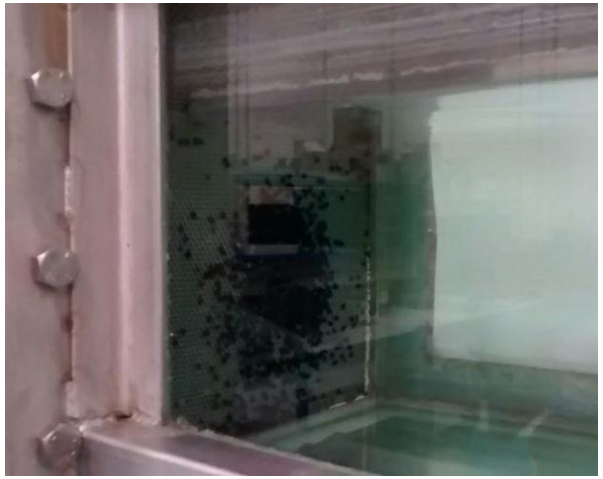
Stable vortex tube > 30 m

VORTEX GENERATION

Experimental validation

Particle injection point

Black particles at a mesh



AGITATION CAPACITY

SBTech benefits:

- ✓ Higher frequency of the light-darkness cycles
- ✓ Homogenization of nutrients
- ✓ Deeper ponds and higher volume of the bioreactor
- ✓ Easier sludge removal
- ✓ Less anoxia problems
- ✓ Higher biomass productivity (biogas)
- ✓ Higher decrease of DBO and DQO and COD
- ✓ Higher N and P removal

CONCLUSIONS

- ✓ The highest **driving efficiency** has been obtained using **large propeller pumps**
- ✓ The influence of the **curve design** in head losses is less important in large raceways
- ✓ Complex CFD reproduce the behavior around **paddle-wheels** showing **transverse vortex tubes** which decay rapidly
- ✓ **Stirring** of algal culture can be enhanced by **stable longitudinal vortex tubes generated by streamlined bodies**
- ✓ **CFD** has been proved to be a good **design tool** to improve the performance of **raceways** at **industrial scale**

*This study has been financed by the **H2020 INCOVER Project***

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